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CHAPTER I

INTRODUCTION AND HISTORY OF PROBLEM

Previous experimental investigations of retroactive inhibition have come to contradictory conclusions. Müller and Pilzecker[1] and Heine[2] found what they believed to be decided evidence for retroactive inhibition. De Camp,[3] on the other hand, found little or no evidence for it.

The present investigation, though undertaken from a different point of view, may throw some light upon this contradiction. At any rate, it has discovered that, in the case of certain contrasted conditions of learning, the one condition may show decided evidence for retroactive inhibition, while another contrasted condition shows little or no evidence for it.

Previous Investigations

Before proceeding to a statement of our special methods and results, we may briefly summarize the previous work.

Müller and Pilzecker

To Müller and Pilzecker we first owe the concept of retroactive inhibition. They presented a series of experiments specifically designed to show that the introduction of enforced mental activity immediately succeeding the learning of a list, exerts an inhibitory effect upon the later memory for that list. This they established, not only by the use of their own method of Right Associates (Treffermethode), but also by that of the Ebbinghaus[4] or Müller and Schumann[5] Savings method (Ersparnismethode).

With the method of Right Associates they performed five experiments. We may briefly epitomize the conditions.

[1] Müller, G. E., and Pilzecker, A. Zeitschrift für Psychologie, Ergänzungsband I. 1900.

[2] Heine, R. Zeitschrift für Psychologie 68, 1914, pp. 161-236.

[3] De Camp, J. E. Psychological Monographs, Vol. XIX, 1915. No. 4.

[4] Ebbinghaus, H. Über das Gedächtnis, Leipzig, 1885.

[5] Müller, G. E., and Schumann, F. Zeitschrift für Psychologie, 6, 1893-4, pp. 81-190 and 257-339.

In the case of each experiment the results were compared for two sets of lists. These differed only as to the manner in which the interval between learning and test was filled. For the one set of lists (Hauptreihen), some form of mental activity, "work," such as learning another list or studying pictures (Aussage test) was enforced upon the subject immediately after learning. For the other set of lists (Vergleichreihen), the interval between learning and test was left entirely free.

The exact conditions and the results we have summarized in

TABLE I.

		TL	Interval	R	r	Tr
Exp. 31(a) (n=144)	V	6 min.	: Rest 6 min.	8	48	2480
Subject Frau P	H	7min. 43.2sec.	: Rest 34.4 sec.; Ll 68.8 sec.; Rest 6 min.	8	23	3570
Exp. 31(b) (n=72)	V	24 hrs.	: Rest followed by usual activities.	16	36	3460
	H	24 hrs.	: Rest 1 min.; Ll 2 min. 17.6 sec.; usual activities.	16	22	3660
Exp. 32 (n=162)	V	8 min.	: Rest 8 min.	12	55	3070
Subject Dr. Behrens	H	10min. 4.6sec.	: Rest 17.8 sec.; Ll 1 min. 46.8 sec.; Rest 8 min.	12	27	3230
Exp. 33 (n=72)	V	8 min.	: Rest 8 min.	6	72	2090
Subject Frau M	H	9 min. 39 sec.	: Rest 27 sec.; Ll 1 min 12 sec.; Rest 8 min.	6	43	2260
Exp. 34 (n=144) Subject Frau P.	H_2	1.5 hrs.	: Rest 6 min.; Ll 1 min. 48 sec.; Rest 10 min., followed by other activities.	12	49	3000
	H_1	1.5 hrs.	: Rest 17.2 sec.; Ll 1 min. 48 sec.; Rest 10 min., followed by other activities.	12	28	2760
Exp. 35 (n=108)	V	8 min.	: Rest 8 min.	8	56	2490
Subject Dr. Behrens	H	8 min.	: Asge. 2 min.; Rest 6 min.	8	24	2950

Table I. H stands for Hauptreihen, V for Vergleichreihen, n for the total number of syllable-pairs in each kind. Under "Interval" are given the duration and disposition of the time between learning and test. TL gives the total length of the interval. Ll stands for learning another similar list, Asge for Aussage experiment. R stands for the number of repetitions given in the original learning; *r* for the percentum of successes; and T*r* for the average response time for the successes.

Experiment 34 alone needs special mention. In this experiment the two sets of lists compared are both followed by work, but for the one set, the H_1 lists, the work followed immediately (in 17.2 sec.), while for the other, the H_2 lists, it followed only after 6 minutes.

The table shows that in the case of all five experiments there appeared to be greater inhibition for the lists followed immediately by work than for those followed immediately by rest.

We turn now to experiments in which the Savings method

TABLE II.

		TL		Interval	R	Rel
Exp. 36(a) (n=8)	V	½ hr. or more depending on order of lists	:	Rest 4 min.; Other lists and rests; Rest 10 min.	5	11.25
Subject Frl. Brinkman	H	"	:	Ll (another list completely learned); Rest 4 min.; Other lists and rests; Rest 10 min.	5	13.0
Exp. 36(b) (n=32)	V	15 min. or more depending on order of lists	:	Rest 4 min.; Other lists and rests; Rest 5 min.	4	6.6
Subject Frl. Brinkman	H	"	:	Ll 1 min. 20 sec.; Rest 4 min.; Other lists and rests; Rest 5 min.	4	7.8
Exp. 37 (n=24)	V	15 min. or more depending on order of lists	:	Rest 4 min.; Other lists and rests; Rest 5 min.	5	4.9
Subject Frau P.	H	"	:	Asge 2 min.; Rest 4 min.; Other lists and rests; Rest 5 min.	5	8.0

was used. Table II presents the conditions and results. Rel. stands for average number of repetitions required in the relearning. n now stands for the number of *lists* of each kind.

These experiments also show greater inhibition for the H lists.

Heine

The primary object of her experiments was to determine whether or not retroactive inhibition plays the same part for recognition memory that Müller and Pilzecker had established for it in connection with recall memory. Nineteen experiments using the Recognition method were performed. In not one of these was evidence of inhibition found. In addition, however, to these nineteen experiments using the Recognition method, fourteen others, using either the Right Associates method or the Savings method, were performed to see, in the first instance, if the results of Müller and Pilzecker would be substantiated, and later to see if some additional laws might be added.

The conditions of the first four of these fourteen experiments were almost identical with those of the Müller and Pilzecker experiments. See Table III.

TABLE III.

		TL		Interval	R	*r*	T*r*
Exp. 13 (n=126)	V	8 min.	:	Rest 8 min.	8	17.5	2445
Subject R	H	8 min.	:	Asge 2 min. Rest 6 min.	8	6.4	3503
Exp. 14 (n=108)	V	8 min.	:	Rest 8 min.	10	57.4	1395
Subject Sch	H	8 min.	:	Asge 2 min. Rest 6 min.	10	36.1	1557
Exp. 15 (n=72)	V	1.5 hrs.	:	Rest 6 min., other activities.	12	36.1	2450
Subject Bl	H	1.5 hrs.	:	Ln 4 min., other activities.	12	9.7	2837
Exp. 16 (n=84)	V	24 hrs.	:	Rest 6 min., other activities.	15	37.7	2123
Subject M	H	24 hrs.	:	Ln 4 min., other activities.	15	35.4	2987

In experiments 15 and 16, the work consisted in learning a list of eight four-place numbers (Ln). The other symbols are the same as for previous tables.[6]

It will be observed that all four experiments gave definite evidence of inhibition.

We turn now to five experiments performed by Heine to discover whether retroactive inhibition plays a part not only as regards association between successive syllables, but also as regards associations within the single syllable. To test this question, a procedure similar to the preceding was adopted, save that the final test consisted in the presentation of two letters of each syllable, and asking for the third letter, instead of in the presentation of the first syllable of each pair, and asking for the second syllable.

The individual conditions and the results have been summarized in Table IV.

TABLE IV.

		TL		Interval	R	r	Tr
Exp. 17 (n=216)	V	9 min.	:	Rest 9 min.	8	48.6	2799
Subject D	H	9 min.	:	Ln 3 min., Rest 6 min.	8	35.2	3443
Exp. 18 (n=216)	V	9 min.	:	Rest 9 min.	12	37.7	1993
Subject R	H	9 min.	:	Ln 3 min., Rest 6 min.	12	27.6	2940
Exp. 19 (n=216)	V	9 min.	:	Rest 9 min.	8	73.6	1707
Subject S	H	9 min.	:	Ln 3 min., Rest 6 min.	8	56.9	1993
Exp. 20 (n=144)	V	9 min.	:	Rest 9 min.	10	32.7	3935
Subject Scho	H	9 min.	:	Ln 3 min., Rest 6 min.	10	15.9	5601
Exp. 21 (n=216)	V	9 min.	:	Rest 9 min.	12	47.7	3784
Subject R	H	9 min.	:	Ln 3 min., Rest 6 min.	12	38.0	4237

[6] When the Savings method is used n stands for the number of *lists* in each group; where the Right Associates method is used, for the number of *syllable pairs* in each group.

We observe a decided effect of inhibition in each of the five experiments.

In the last five of the fourteen experiments the author seeks to discover if strongly impressed associations are relatively less affected by retroactive inhibition than are weak ones.

In the first one of these last five experiments the method of Right Associates was used as in the previous experiments, but in each hour four lists were learned: an H and a V list, and an h and a v list. The H and the V lists differed from the h and the v lists only in that they were given a greater number of repetitions in the original impression, and were recalled after a longer interval than the h and v lists. The other conditions and the results are shown in Table V.

TABLE V.

		TL		Interval	R varied from	r	Tr
	V	24 hrs.	:	Rest 9-10 min.	30-20	62.0	2406
Exp. 29 (n=108) Subject Rot	H	24 hrs.	:	Ln 3 min., Rest 6-7 min.	30-20	36.2	3013
	v	9 min.	:	Rest 9 min.	6-2	70.4	1939
	h	9 min.	:	Ln 3 min., Rest 6 min.	6-2	21.1	2683

The expected result appears. While the r for the v list is distinctly bigger than that for the V lists, the r for the h lists is smaller than for the H lists.

In the two next experiments the author employed not the Right Associates method but the Savings method. In these two experiments also there were V, H, v, and h lists. The v and h lists were given a small number of repetitions in the original learning, the V and H lists a large number. After an equal interval of time all four lists were relearned.

The results appear in Table VI.

R stands for the numbers of repetitions in the original learnings. Rel stands for the numbers of repetitions in the relearnings; the figures outside the brackets are means, those within the brackets medians.

TABLE VI.

		TL		Interval	R	Rel
	V	1.5 hrs.	:	Rest and other activities.	8	25.2 (26.5)
Exp. 30 (n=24)	H	1.5 hrs.	:	Ln 3 min. Rest, other activities.	8	25.2 (24.0)
Subject Ruv	v	1.5 hrs.	:	Rest and other activities.	4	21.2 (21.5)
	h	1.5 hrs.	:	Ln 3 min. Rest, other activities.	4	22.0 (23.0)
	V	1.5 hrs.	:	Rest and other activities.	12	24.2 (24.0)
Exp. 31 (n=24)	H	1.5 hrs.	:	Ln 3 min. Rest, other activities.	12	25.3 (25.0)
Subject R	v	1.5 hrs.	:	Rest and other activities.	6	20.3 (19.5)
	h	1.5 hrs.	:	Ln 3 min. Rest, other activities.	6	22.5 (23.0)

Again we note a bigger inhibition for the h lists than for the H lists.

In her last two experiments the author returned to the method of Right Associates. The experiments were performed on two subjects who had given evidence of inhibition in two of the earlier experiments. Here these same two subjects were given a greater number of repetitions. For the sake of comparison, Table VII gives the results both for the two earlier experiments and for the two new ones.

TABLE VII.

		TL		Interval	R	*r*	Tr
Exp. 32 (n=144)	V	0.5 hrs.	:-	Rest.	25	22.2	5955
Subject R	H	0.5 hrs.	:	Pictures 3 min. Rest.	25	20.2	5161
Exp. 13 (n=126)	V	8 min.	:	Rest 8 min.	8	17.5	2445
Subject R	H	8 min.	:	Asge 2 min. Rest 6 min.	8	6.4	3503
Exp. 33 (n=72)	V	24 hrs.	:	Rest.	25	11.1	2030
Subject Sch	H	24 hrs.	:	Pictures 3 min. Rest.	25	16.7	1946
Exp. 14 (n=108)	V	8 min.	:	Rest 8 min.	10	57.4	1395
Subject Sch	H	8 min.	:	Asge 2 min. Rest 6 min.	10	36.1	1557

Again we find less inhibition in the case of the more strongly impressed associations.

Summing together the results of Heine's fourteen experiments, we can conclude that they seem pretty definitely to substantiate the findings of Müller and Pilzecker as regards retroactive inhibition, and that they indicate a greater degree of such inhibition for the more weakly impressed associations.

Let us now turn to De Camp's findings. We shall see that they contradict those of Müller and Pilzecker and of Heine.

De Camp

This author started with the assumption that the existence of retroactive inhibition had been definitely demonstrated by Müller and Pilzecker,[7] and sought to determine the relative degrees of such inhibition produced by various amounts and different distributions of work. He obtained results, however, which ultimately led him to doubt the experimental importance of retroactive inhibition under *any* conditions. We will present a brief review of his experiments, but for convenience's sake will take them up in somewhat different order from that in which he himself presents them.

First we will consider a group of experiments in which the conditions are very similar to those of Müller and Pilzecker and of Heine.

As work in most of these experiments multiplication was used. In one experiment, however, physical (ergographic) work was used; in a second, problem solving; and in a third, chess-playing. In one experiment the syllables were presented auditorily instead of visually. The results are presented in Table VIII. The caption "work," unless otherwise designated, means multiplication.

Examining the table, we find four out of the seven experiments in which both r values and times indicate inhibition. In two of the others (Experiments VII-VIII) the r values are for

[7] De Camp seems to have missed the final report of Fraulein Heine's work, and to have been acquainted only with the abbreviated report presented by Prof. G. E. Müller at the V. Kongress für experimentelle Psychologie, in Berlin, 1912.

TABLE VIII.

		Interval	R	r_1	Tr
Subject B					
Exp. III	V	Rest 15 min.	10	48	2221
(n=112)	H	Work 10 min., Rest 5 min.	10	33	2673
Subject D					
Exp. V	V	Rest 15 min.	10	34	5149
(n=70)	H	Work 15 min.	10	30	5822
Subject W					
Exp. VI	V	Rest 15 min.	10	79	2828
(n=63)	H	Work 10 min., Rest 5 min.	10	68	2955
Subject W					
Exp. VII Auditory	V	Rest 15 min.	6	41	5127
(n=70) presentation	H	Work 10 min., Rest 5 min.	6	40	4286
Subject D					
Exp. VIII*	V	Rest 16 min.	10	67	4862
(n=63)	H	Adj. 1 min., Erg. 10 min., Rest 5 min.	10	43	4108
Subject Z B					
Exp. IX (b)	V	Rest 15 min.	10	53.6	5238
(n=56)	H	Solving problems 6 min., Rest 9 min.	10	46.4	5593
Subject P					
Exp. XI	V	Rest 15 min.	8	40	2343
(n=70)	H	Chess 10 min., Rest 5 min.	8	50	2392

*It was in this experiment that ergographic work was substituted for mental work. One minute was required for adjusting the ergograph. This was followed by ten minutes work with the instrument. The subject was harnessed so that he lifted the weight from the shoulders.

†The original monograph gives the total numbers of correctly recalled syllables, the numbers of partially correct syllables, and the averages, medians, and mean variations for the completely correct syllables, in addition to r, the percentages of completely correct syllables. For comparison with the results of Müller and Pilzecker and of Heine as given by them, we here present the r values only.

inhibition, but the times are against it. In the third (Exp. XI) *r* values are against inhibition but times are for it. We conclude that these seven experiments, taken as a whole, do not give nearly the same evidence for inhibition as did the similar experiments of Müller and Pilzecker and of Heine.

In each of the next four experiments to be considered, a large number of different distributions of rest and work were examined. In the first two of these four, the fifteen minute interval between learning and test was distributed in 16 different ways: Rest 15, Work 0; Rest 14, Work 1; Rest 13, Work 2; Rest 12, Work 3; etc.—to Rest 0, Work 15. The Rest always preceded the Work. In the last two of the four experiments, the last nine minutes of the total 15 were spent in rest, but the first 6 minutes suffered different distributions, as follows: Rest 0, Work 6, Rest 9; Rest 1, Work 5, Rest 9; Rest 2, Work 4, Rest 9; etc.—to Rest 6, Work 0, Rest 9. It is to be noted that for both sets of distributions there was only one form in which the Work followed immediately after the learning, viz., Rest 0, Work 15; and Rest 0, Work 6, Rest 9. We will compare the results for these two distributions, in which work follows immediately and for which it would seem that inhibition, if it appears at all, should be a maximum, with the distributions in which there was no work, but complete rest. The comparison is given in Table IX.

Examining Table IX, we note that the *r* values indicate inhibition in only one experiment, the T*r* values in two experiments. The evidence certainly seems to be quite as strongly against inhibition as in favor of it.

We may quote, finally, three other experiments performed by De Camp in which similar results were obtained. In the first of the three (Exp. IV), two distributions of the form Rest 6. Work 9 and Rest 2, Work 13 were examined. In the third (Exp. XIII), the Reconstruction method was used. The memory test consisted in this case in trying to reconstruct an arrangement of five chessmen which had been exposed for 15 seconds three minutes before. The work consisted in arithmetic. For the results and further conditions of all three experiments, see Table X. In the case of experiment 13, the average number of

TABLE IX.*

		Interval	R	r	Tr
Exp. I (n=28)	V	Rest 15 min.	16	18	2250†
Subject B	H	Rest 0 min., Work 15 min.	16	18	4250†
Exp. II (n=56)	V	Rest 15 min.	16	50	6700†
Subject F	H	Rest 0 min., Work 15 min.	16	55	6850†
Exp. IX(a) (n=140)	V	Rest 15 min.	10	41	6349
Subject Z B	H	Rest 0 min., Work 6 min., Rest 9 min.	10	31	4669
Exp. X (n=42)	V	Rest 15 min.	10	33	2500
Subject A	H	Rest 0 min., Work 6 min., Rest 9 min.	10	36	1249

misplacements per test is given under the caption "errors," and the average number of seconds required for the reconstruction under that of "time." n in the case of this experiment represents the number of tests made.

TABLE X.

		Interval	R	r	Tr
Exp. IV (n=70)	H_1	Rest 6 min., Work 9 min.	10	29	2675
Subject B	H_2	Rest 2 min., Work 13 min.	10	37	3328
Exp. XII (n=14 per subject) 34 Subjects	V	Rest 15 min.	12	42.5	2047
	H	Solving problems 6 min., Rest 9 min.	12	42.0	2184
			Errors	*Time*	
Exp. XIII (n=36)	V	Rest 3 min.	10.4	67.4 secs.	
Subject Z B	H	Arithmetic 2 min., Rest 1 min.	11.7	66.2 secs.	

*A number of the figures given in this table and the next were not presented as such in De Camp's text, but have been computed by the writer from values that were given, or from plots.

†Approximate, estimated as accurately as possible from plot given in text.

It will be observed again that no one of the three experiments gives certain evidence of inhibition and that experiment IV seems to point decisively in the opposite direction.

Summing up the total results of De Camp's fourteen experiments, we must conclude with him that they afford no such clear evidence for inhibition as that afforded by the results of Müller and Pilzecker and of Heine.

Let us now turn to our own experiments.

CHAPTER II

PLAN OF INVESTIGATION

These experiments, like those of De Camp, started with the supposition that retroactive inhibition had been definitely established.[1] They originated with the idea that lists made up of numbers and *indifferent* words (i.e., words of indifferent meaning) might be more affected by retroactive inhibition than lists made up of numbers and *pleasant* words. In testing this possibility, results were obtained similar to those of De Camp, in so far as little evidence of inhibition was found. But what evidence there was was always on the side of more inhibition for the *indifferent* lists and less for the *pleasant* lists. This result seemed significant, and it occurred to us to look for another pair of contrasted conditions which might operate in the same sense as pleasantness and indifference, but with more certainty. Our first attempt at finding such a pair led to an experiment in which learning with *normal attention* was contrasted with learning with *artificially distracted attention*. The results were disappointing. Retroactive inhibition was not found for either kind of attention. Two further pairs of contrasted conditions were tried. The results in these cases were successful. Lists learned under *caffeine* were found to be less affected by retroactive inhibition than those learned *without caffeine*. Lists learned in the morning *(efficient hour)* were found to be less affected by inhibition than lists learned in the evening or directly after the noonday meal *(inefficient hour)*.

We turn to a presentation of technique.

[1] They were begun before De Camp's results were published. They were performed during the summer vacations of 1914, 1915, and 1916 and in the winter semester of 1915-1916.

CHAPTER III

TECHNIQUE

I. Apparatus.

A Hipp chronoscope was not available to measure response times (Trefferzeiten).[1] In the earlier experiments these times were, therefore, not measured. In later experiments, however, a stop watch with an electric magnet for starting and stopping was used. The magnet was connected in one circuit with the falling shutter, and in another with the lip key.

Two styles of lip key were used: In the one style (A), the contacts were so arranged that the opening of the key *made* the circuit. This key when used was connected directly into the magnet circuit. In the other style (B), the opening of the key *broke* the circuit. This key, therefore, when used was connected into the magnet circuit through a relay.

The apparatus for presenting the lists differed for different experiments. In some it consisted of a Rupp-Lipmann Gedächtnisapparat;[2] in others of a kymograph drum connected by pulleys and belts with a 110 V D. C. motor; and in one experiment of a kymograph drum connected with a gravity motor.[3] The Rupp-Lipmann apparatus presented the material in step-wise fashion, i.e., the drum stopped moving for an instant when the syllable reached the middle of the exposure slit. The kymograph drums, on the other hand, revolved continuously.

The speeds of the Rupp-Lipmann apparatus and the gravity motor were absolutely constant. That of the electric motor, on the other hand, although fairly constant throughout any one working hour, varied from one working hour to the next by as much as 2 seconds per revolution of the kymograph drum.

[1] The method of right associates (Treffermethode) was used throughout.

[2] Made by Max Marx, Berlin. Loaned from the Harvard Psychological Laboratory by the kindness of Prof. H. S. Langfeld to whom the writer's thanks are due.

[3] Also loaned by the Harvard Laboratory.

II. Construction of Lists, and of Material for "Work."

(A) Word-lists and Number-lists used in Pleasant vs. Indifferent Experiments. (Exps. 1, 2, 3, and 4.)

The complete stock of words from which the words for these lists were drawn consisted of two- and three-syllable adjectives and nouns. The pleasantness or indifference of the individual words in this stock had been subjected to the judgment of a number of individuals. In Experiment 1, the writer alone had passed judgment, and determined which words should go in the pleasant lists and which in the indifferent. In all the other experiments, however, several persons had judged the words.

In the case of the all-word lists (used in some subsidiary experiments performed in connection with the main experiments), the two- and three-syllable words were alternated.

In the number-word lists, the numbers were alternated with the words, the two- and three-syllable words occurring in a specific order. In Experiment 1, the same words which had been used in the all-word lists of the prior subsidiary experiment were used over again in the number-word lists of the main experiment. In Experiment 2, *some* of the same words were used over again. In Experiments 3 and 4, none of the words used in the subsidiary experiments were used in the main experiments.

The numbers used in the number-word lists were in Experiment 2, two-place, in Experiments 1, 3, and 4, three-place. The two-place ones were drawn from a stock consisting of the numbers between 21 and 98 inclusive, with the omission of those ending in 0, and of those in which the same digit appears twice; the three-place ones from a stock consisting of the numbers between 123 and 987 inclusive, with the omission of those containing 0, of those containing the digit 1 in the second place and of those in which the same digit appears twice.

In constructing the lists, the numbers were drawn by chance with the following restrictions:

(a) Two numbers containing the same digit in the same place, such as 348 and 745, or 63 and 65, were always separated in any one list by at least two intervening numbers.

(b) In the case of the lists which were used in the same experiment hour, the number of times in which the digit 1 appeared was made the same in every list.

(c) In using the two-place numbers, the same number was never repeated in the same experiment hour. In using the three-place numbers, the same number was not repeated at all during the course of the experiment.

(B) Nonsense Syllable Lists. (Exps. 6, 7, 8, 9, 10, 11, 12, and 13.)

These were constructed according to the Müller and Schumann rules of "verschärfte Normalreihen,"[4] but using English consonant and vowel combinations instead of German ones. All syllables which were the same as actual words, either in spelling or in pronunciation, were rejected.[5] As initial consonants were used b, d, f, g (pronounced as in "gain"), h, j (pronounced as in "jewel"), k, l, m, n, p, r, s, t, v, w, z, and sh; as terminal consonants, b, d, f, g (pronounced as in "dog"), k, l, m, n, p, s, t, v, z, sh, and ch; and as vowels, ā, ă, ē, ĕ, ī, ĭ, ō, ŏ, ū, ŭ and the two diphthongs ōū (pronounced as in "house"), and oĭ (pronounced as oy in "boy"). The diacritical marks were always given.

(C) Mixed Nonsense Syllable-Word Lists. (Exp. 5.)

These lists were made up by alternating nonsense syllables with one-syllable English words. The nonsense syllables were taken directly from a "verschärft normal" series constructed as just described, the words from some "normal" word-lists.[6] In alternating the syllables and the words, the following prescriptions were used:

(a) No word or nonsense syllable was allowed to have the same vowel sound, the same initial consonant sound, or the same terminal consonant sound, as the immediately preceding or the immediately succeeding nonsense syllable or word.

(b) No word or nonsense syllable was allowed to begin with the same consonant sound that the preceding nonsense syllable or word ended with; and vice versa, no word or nonsense syllable was

[4] Müller and Schumann, op. cit., p. 106.

[5] Müller and Schumann did not eliminate single syllables which spelled words, but merely syllable combinations, such as "gib nur," or "weib lich," which spelled words or phrases. The relatively greater number of monosyllabic words in English as compared with German made our further restriction necessary.

[6] These one-syllable word lists had been made up for use in other experiments according to rules very similar to those for "Normalreihen."

allowed to end with the same consonant sound that the preceding nonsense syllable or word began with.

(D) Material Used after Learning of Lists to Produce Inhibition.

As an activity following immediately after the learning, and intended to produce retroactive inhibition, we used, as did Fraulein Heine,[7] the learning either of tables of numbers or of tables of colored consonants. These tables were constructed in the same manner in which hers were.

III. Methods of Procedure and of Presentation of Data; Subjects.

For convenience, we may speak of learning of *pleasant* lists, learning under *caffeine,* and learning in an *efficient hour* of the day, under the single head of "More Stimulating" learning (M), and learning of *indifferent* lists, learning *without caffeine,* and learning in an *inefficient hour,* under the contrasted head of "Less Stimulating" learning (L).[8]

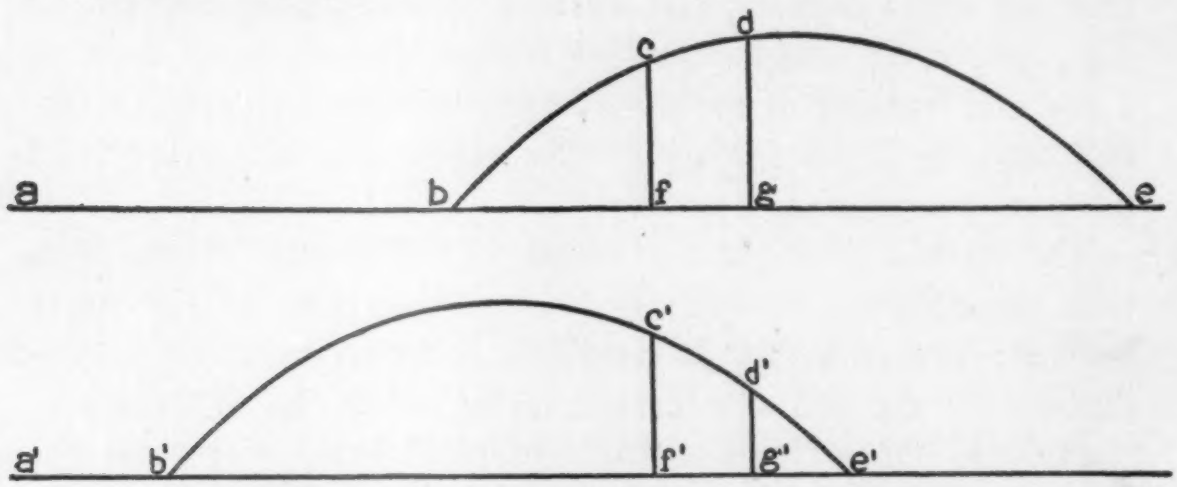
The method of Right Associates (Treffermethode) has been used throughout. In each experiment four sets of lists were learned: two under the M condition, and two under the L condition. Of the two sets learned under either one of these two conditions, one set consisted of "passive" lists. For these the entire interval between learning and test was left unoccupied, and the subject was instructed to remain as mentally "passive" as possible, and not to think of the lists. The other set consisted of "work" lists. These were followed immediately by a two or three minutes memorizing of numbers or consonants. In

[7] Op cit., pp. 172, 179.

[8] We are primarily justified in grouping the three contrasts under this single head because we are to find that they act similarly with regard to retroactive inhibition. The particular names "More" and "Less Stimulating" were chosen, however, on the basis of other common characteristics aside from that of similarity as to inhibition. It will be shown that the "More Stimulating" conditions seemed to require fewer repetitions for the same degree of learning; that, in the cases of with caffeine vs. without caffeine and of efficient hour vs. inefficient hour, they produced more "work"; and, finally, that the average times of the correct responses were shorter for them than for the "Less Stimulating" conditions. Hence the choice of the terms "More" and "Less Stimulating."

the latter part of the interval, between learning and test, the subject remained passive.

In order that the results of these four sets of lists, which we may term the P and W (M condition), and the p and w (L condition), respectively, may indicate conclusively that the L condition was more affected by retroactive inhibition than the M condition, one definite prescription must be fulfilled. Not only must the difference (r^9 for p lists)—(r for w lists), be greater than the difference (r for P lists)—(r for W lists), but also r for the p lists must itself be equal to or greater than that for the P lists, while that for the w lists must be smaller than, or no greater than, that for the W lists. The following reasoning makes this clear.[10]



Let the curve bcde represent, at the time of testing, the distribution of association strengths for passive lists of the M condition. The abscissae will stand for association strengths, the ordinates for the frequencies of these strengths. Let distance af represent the threshold. The size of area fce will thus measure the percentage of correct responses, (i.e., r) for the P lists. Let the association strengths for the Work lists of the M condition have á similar distribution, save that the entire curve may be considered shoved to the left, nearer the origin. (This assumes, of course, that work will exert an inhibitory effect, and that the amount of this effect will be approximately equal

[9] Following the precedent of Müller and Pilzecker, we have let r designate the percentage of correct responses.

[10] This discussion is taken from Heine, op. cit., pp. 212-215.

for associations of different absolute strengths.) We may represent this displacement of the work curve as equal to the distance fg. Or, in other words, we may let area gde represent the percentage of correct responses (i.e., *r*) for the W lists. It follows, then, that area fcdg may represent the drop in *r* from the P lists to the W lists or (*r* for P lists)—(*r* for W lists).

Turn now to the case of the lists for the L condition. Let us assume that the form of distribution is the same as for the M condition, but that, given the same number of repetitions per list, the association strengths established for the L condition all tend to be weaker than those for the M condition. This may be represented by drawing the curve for the p lists displaced to the left of that for the P lists, or, in short, by curve b′c′d′e′. The threshold is the same as before, and hence area f′c′e′ now represents *r* for the p lists, and assuming an exactly equal inhibition produced by the work in both cases, area g′d′e′ will represent *r* for the w lists. It is evident that the drop in *r* will appear less than it did in the case of the M condition, i.e., area f′c′d′g′ is less than area fcdg. It is therefore plain that in order for the differences between *r* for the passive lists and for the work lists to give a sure indication of the true differences in degree of inhibition for the two cases, the same portions of the distribution curve must be affected.

It follows that, if we are to prove conclusively that the L condition is really more affected by retroactive inhibition than the M condition, we must regulate our results (by extra repetitions, if necessary, in the case of the L condition), so that *r* for the p lists is equal to or greater than that for the P lists. Only then will a greater difference of (*r* for p lists)—(*r* for w lists) than (*r* for P lists)—(*r* for W lists) indicate conclusively that the L condition was more affected by work.

As a result of such reasoning, in each of our experiments more repetitions were given on the average in the L condition than in the M condition. Furthermore, the numbers of repetitions were varied from time to time during the course of a single experiment, if variations in the freshness or practice of a subject seemed to make it necessary, to insure an equal or greater *r* for the p

lists than for the P lists. In changing the number of repetitions, however, those for the w lists were of course always kept equal to those for the p lists, and those for the W lists to those for the P lists.[11]

Other peculiarities of method were as follows.

A day or more of practice always preceded each actual experiment.

Successive experiment-days did not always coincide with successive calendar days, but did so as nearly as possible. The experiment-hours were kept the same throughout any one experiment.

The positions of the p, w, P. W lists within the experiment-hour were interchanged from day to day. This occurred either according to a regular sequence (Systematic variation of "time-position"), or in an irregular manner (Irregular variation of "time-position"). In either case a 'Cycle" of variations involved a complete interchanging of lists such that each kind of list had occupied each position within the hour (i.e., each time-position) an equal number of times.

The intervals between testing one list and learning the next were always short, averaging less than a minute. They were merely long enough to prepare the apparatus for the next list. Such short waits were necessary in order not to put too great a demand upon the subject's time.[12]

As "work," the checker-board arrangements of either 25 two-place numbers or 25 differently colored consonants were studied by the subject for a prescribed interval (either 2½ or 3 minutes), and then recalled orally.

The "passive" intervals were usually spent by the women subjects[13] in sewing or knitting. They were spent by the men in

[11] A similar procedure was adopted by Heine in experiments upon the relative inhibition of weak and strong associations. Op. cit., p. 217, and see also above p. 6.

[12] It is probable that this increased the unevenness in learning-value of the different time-positions.

[13] There was one exception. In the case of Exp. 5, subject T. spent her time in glancing through the newspaper or a pile of magazines.

resting in an easy chair, in walking about the room, or glancing through a pile of magazines.[14]

Introspection during the course of the experiments was not asked for, but was noted when given. This procedure was adopted in accordance with Müller's prescription for reliable objective results.[15]

In presenting the results, we have given only (1) the mean percentum of correct responses and (2) the median percentum of correct responses. We have not presented mean variations, because they might tend to give a false idea of lack of precision in our results. The effect of such factors as practice and time-positions is to make the mean variations large. But since these factors are made as nearly as possible the same for each kind of lists, the size of the mean variations is not a fair test of the precision of the final comparison.[16] A more reliable way of determining precision would seem to lie in the examination of the results for the individual "cycles." These we have presented.

Our subjects were as follows: Mr. E. Norris (N), graduate student in psychology; Mr. L. Vernon (V), undergraduate student in psychology; Mrs. A. P. Carter (C), no psychological training; Miss E. C. Carter (Ca), no psychological training; Mrs. E. C. Tolman (T), no psychological training; and the author (To).

In every experiment, save that in which the writer was the subject, there was complete ignorance on the part of the subject of the purpose of the experiment. Furthermore, in the experiment in which the writer was subject, the arrangement was such that his knowledge of the purpose could not conceivably affect his results one way or the other.

[14] In some preliminary experiments and in Exp. 6, the subject listened to dropping water while lying in an easy chair with eyes closed. It was thought that such complete abstraction in the "passive" intervals might make the inhibitory effect produced by the "work" intervals appear bigger. No such influence was discovered.

[15] Müller, G. E. Zeitschrift für Psychologie, Ergänzungsband 5, 1911, p. 130.

[16] See Müller, G. E. a,nd Schumann, F., op. cit., pp. 266-279.

CHAPTER IV

PRESENTATION OF RESULTS

I. Pleasant vs. Indifferent Lists. Exps. 1, 2, 3, and 4.

In connection with each of these experiments an attempt was made to show independently by means of simple learning tests the relatively greater stimulating value of the pleasant lists as opposed to the indifferent lists.[1] In Experiments 1 and 2, this determination was made by means of subsidiary experiments performed prior to the main experiment. In Experiments 3 and 4 it was done as part of the main experiment.

In all the experiments the subjects were told before the presentation of each list whether it was to be pleasant or indifferent. It was hoped that this would increase the subjective difference between the two kinds of lists.

Experiment 1. Subject C.

Subsidiary Experiment. All-word lists (10 words each), method of Complete Learning (Erlernungsmethode), R. L. Gedächtnisapparat. Time of one revolution 10.8 sec. Six lists learned in an experiment hour: two pleasant lists, two indifferent lists, and two unpleasant lists.[2] Systematic variation of the time-position of lists. Cycle complete in three exp. hours.

Results. (6 exp. days, n=12.)

	R	
Pleasant	11.5	(12.0)
Indifferent	12.7	(12.5)
Unpleasant	13.5	(13.0)

Under the caption R are given the average numbers of repetitions for a successful recitation (inclusive of the recitation). The figures in brackets give the median values.[3] n is the number of each kind of list learned.

[1] See above footnote, p. 17.

[2] The inclusion of the unpleasant lists was the result of an original purpose of investigating thoroughly the effects of unpleasant as well as pleasant feeling-tones, a purpose which was afterwards abandoned.

[3] These medians and all the others which we shall present in this paper were obtained simply by arranging the figures in order of magnitude and taking the middle one in the case of an odd number of figures or taking an average of the two middle ones in the case of an even number of figures.

The results seem to indicate that pleasant words were for this subject more stimulating, in the sense at least of being more readily learned, than were indifferent words.

Main Experiment. R. L. apparatus. Time of one revolution 10.8 sec. Reproduction times not measured. Ten-place lists of alternate three-place numbers and words. Systematic variation of the time-position of the lists. Cycle of variation complete in four experiment hours. Repetitions: pleasant lists 3-2, average 2.5; indifferent lists 4-2, average 3.1. Time-interval[4] 9 minutes. Work: 3 min. studying checker-board of numbers or consonants (on alternate days).

		Pleasant			Indifferent	
		r			*r*	
Complete results.	P	60.0	(60.0)	p	80.0	(80.0)
(8 exp.-days)	W	40.0	(40.0)	w	35.0	(30.0)
n=40						
		Nos.	*Cons.*		*Nos.*	*Cons.*
Work:		15.0	10.5		15.8	10.0
		r			*r*	
First cycle.	P	70.0	(70.0)	p	75.0	(80.0)
(4 exp.-days)	W	45.0	(50.0)	w	40.0	(40.0)
n=20						
		r			*r*	
Second cycle	P	50.0	(50.0)	p	85.0	(90.0)
(4 exp.-days)	W	35.0	(30.0)	w	30.0	(30.0)
n=20						

n here stands for number of number-word pairs in each group of lists.[5] *r* stands for percentages of correct responses. The figures outside the brackets are averages. Those within are medians.[6] P, W, p, and w stand for pleasant lists passive condition, pleasant lists work condition, indifferent lists passive condition, and indifferent lists work condition, respectively. Opposite "Work" are given the average number of numbers (Nos) and colored consonants (Cons) learned after the three minutes study in the case of the work conditions.

[4] By "time-interval" we shall mean the time between the end of the learning and the beginning of the Right Associates test.

[5] Wherever the Savings method is used n will stand for the number of *lists* in each group; wherever the Right Associates method is used, for the number of number-word pairs (or nonsense syllable pairs) in each group.

[6] We computed the median number of correct syllables recalled per list for the condition in question, and divided the figures so obtained by the total number of recalls per list possible (in this experiment, 5).

It will be observed at once that both the complete results and the results for the individual cycles indicate a greater inhibition for the indifferent lists than for the pleasant lists. Not only is the drop in *r* for the indifferent lists in each case greater than that for the pleasant lists, but the values for the indifferent lists are inclusive of those for the pleasant lists.[7]

Turning to the work, i.e., the number of numbers or consonants learned in the three minute period, we note but little difference in the two cases.

We conclude that this experiment points to a real difference between the effects of retroactive inhibition after pleasant learning and after indifferent learning.

Experiment 2. Subject T.

The main experiment was preceded by two subsidiary experiments to determine the relative stimulating values of the two kinds of lists.

Subsidiary Experiment A. All-word lists. Four lists: two pleasant, two indifferent, learned and relearned in each experiment-hour. Systematic variation of the time-positions. Kymograph drum and gravity motor. Time of one rev. 13-14 sec. We present the results for original learnings only.

Results. (3 exp. days, n=6)

	R	
Pleasant	13.8	(14.0)
Indifferent	16.2	(17.0)

Subsidiary Experiment B. This experiment followed subsidiary experiment A, but instead of all-word lists, number-word lists were used (numbers were two-place), and the lists were merely learned, not relearned. Eight lists, four pleasant and four indifferent, were learned in each exp.-hour. Systematic variation of time-position of lists. Kymograph drum and gravity motor. Time of one rev. 10.5 sec.

Results. (2 exp. days, n=8)

	R	
Pleasant	14.3	(15.0)
Indifferent	14.9	(13.5)

Subsidiary Experiment A indicates that the pleasant lists were more stimulating for this subject than the indifferent lists. Subsidiary Experiment B, on the other hand, is non-committal. The results for the medians contradict those for the means.

[7] See above pp. 18-19.

We may turn to the results of the main experiment which followed Subsidiary Experiment B.

Main Experiment. Kymograph drum and gravity motor. Time of one rev. 10.5 sec. Response times not measured. Twelve-place lists of alternate two-place numbers and words. Systematic variation of the time-position of the lists. Cycle of variation complete in four exp.-hours. Repetitions: pleasant lists 10-8, average 8.9; indifferent lists, 10-9, average 9.8. Time-interval 9 mins. Work: 3 mins. of studying checkerboard of numbers or consonants (on alternate days).

		Pleasant			Indifferent	
		r			*r*	
Complete results.	P	52.1	(50.0)	p	60.0	(65.0)
(8 exp.-days)	W	64.6	(66.7)	w	47.9	(50.0)
n=48						
		Nos.	*Cons.*		*Nos.*	*Cons.*
Work:		14.0	10.3		10.6	9.7
		r			*r*	
First cycle	P	62.5	(66.7)	p	74.2	(81.7)
(4 exp.-days)	W	58.3	(58.3)	w	38.5	(33.3)
n=24						
		r			*r*	
Second cycle	P	41.7	(50.0)	p	45.8	(41.7)
(4 exp.-days)	W	70.8	(66.7)	w	58.3	(50.0)
n=24						

The captions have the same meanings here as in the previous experiment.

We may note first as regards the "work" that the number of numbers or consonants learned tended to be greater after the pleasant lists than after the indifferent. Greater inhibition for the indifferent lists was not, therefore, due to harder work after these lists.

Considering the final results for the complete experiment, we note that whereas the figures for the indifferent lists indicate inhibition, those for the pleasant lists indicate facilitation. The question arises whether both effects may not have been the result of chance. Facilitation, it would seem, could only have been due to chance, and if so, why should not the opposite and practically no larger inhibition also have been the result of chance? This is indeed a possibility.

Let us turn, however, to the results for the individual cycles.

It may be remarked, in passing, that in the case of this particular experiment the last experiment day of the first cycle and the first experiment day of the second cycle were separated by an interval of 17 days,[8] so that in a sense the two cycles were more like two independent experiments than like two parts of the same experiment.

In the case of Cycle 1, we find evidence of inhibition for both sets of lists. Furthermore, they support the results of Experiment 1, since the inhibition for the indifferent lists is strikingly greater than for the pleasant lists. In Cycle 2, on the other hand, we find facilitation for both sets of lists. But it must be noted that this facilitation is less for the indifferent than for the pleasant lists. The possibility is therefore suggested that in this cycle, also, there was a real tendency towards inhibition for the indifferent lists as compared with the pleasant lists, but that chance or some other indefinable factor entered in and blurred the results. At any rate, it would seem safe to conclude that, although the total results of Experiment 2, in themselves, may seem to point to no conclusion, the results for the two cycles taken separately and compared with those of Experiment 1 do seem to afford further evidence for the conclusion that indifferent lists have more of a tendency to be inhibited by succeeding work than have pleasant lists.

Let us turn now to Experiments 3 and 4. In these two experiments, the relative stimulating values of the two kinds of lists were measured by means of immediate recall tests carried on as part of the main experiments. In these recall tests, lists of 12 words each, one pleasant list and one indifferent, were presented by means of the kymograph drum. After one revolution of the drum, the subject was asked to recall (in any order) as many of the words as he could.

Experiment 3. Subject V.

Kymograph drum. Electric motor. Time of one rev. 12.0 sec. Response times not measured. Ten-place lists of alternate three-place numbers and words. Systematic variation of the time-position of lists. Cycle of variation

[8] This was the only experiment in which an interval of more than two or three calendar days intervened between successive experiment days.

complete in four experiment-hours. Repetitions: pleasant lists 11-8, average 8.9; indifferent lists 12-10, average 10.9. Time-interval 6 minutes. Work: 3 min. studying checkerboard of consonants.

		Pleasant			Indifferent		
		r	Wds.		*r*	Wds.	
Complete results.	P	52.5	(50.0)		p 52.5	(40.0)	
(8 exp.-days)			6.4				5.8
n=40	W	57.5	(60.0)		w 42.5	(40.0)	
		Cons.			*Cons.*		
Work:		6.4			7.1		
		r			*r*		
First cycle	P	45.0	(50.0)		p 30.0	(30.0)	
(4 exp.-days)	W	45.0	(60.0)		w 35.0	(40.0)	
n=20							
		r			*r*		
Second cycle	P	60.0	(60.0)		p 75.0	(80.0)	
(4 exp.-days)	W	70.0	(80.0)		w 50.0	(50.0)	
n=20							

Under the caption Wds are given the average numbers of pleasant and indifferent words recalled in the immediate recall tests. We see a slight tendency to recall more pleasant than indifferent words. As regards the work, it is to be noted that a slightly greater number of consonants was learned after the indifferent lists than after the pleasant. The difference, however, is small, and probably not enough to have made in itself any difference in the inhibition produced in the two cases.

Examining the main results, we see that the indications in any direction are but slight. The complete figures here, as in the case of the previous experiment, indicate facilitation for the pleasant lists and inhibition for the indifferent. The figures for the individual cycles do not make these final results much clearer. Those for Cycle 1 suggest slight facilitation for both pleasant and indifferent lists, with no appreciable advantage for either. Those for Cycle 2 indicate facilitation for the pleasant lists and inhibition effect for the indifferent lists. We conclude that the results of this experiment taken by themselves would prove but little. When combined, however, with those of the two preceding experiments they add their slight quota of further

testimony to the conclusion that indifferent lists are relatively more affected by inhibition than are pleasant lists.

Let us turn to Experiment 4.

Experiment 4. Subject N.

Conditions exactly the same as in the previous experiment save for the numbers of repetitions. Repetitions: pleasant lists 9-6, average 7.6; indifferent lists 10-8, average 8.6.

		Pleasant			Indifferent		
		r	Wds.		*r*	Wds.	
Complete results.	P	42.5	(30.0)		p 46.3	(50.0)	
(8 exp.-days)				7.4			6.7
n=40	W	55.0	(50.0)		w 47.5	(40.0)	
		Cons.			*Cons.*		
Work:		14.1			14.1		
		r			*r*		
First cycle	P	20.0	(20.0)		p 57.5	(60.0)	
(4 exp.-days)	W	45.0	(30.0)		w 65.0	(60.0)	
n=20							
		r			*r*		
Second cycle	P	65.0	(60.0)		p 35.0	(30.0)	
(4 exp.-days)	W	65.0	(60.0)		w 30.0	(30.0)	
n=20							

These figures need but little separate discussion. They are similar to those for the preceding experiment. Combined with them they add their evidence to the conclusion that indifferent lists tend to be more affected by inhibition than pleasant ones.

Let us sum up as regards these pleasant vs. indifferent experiments. We note that the last three, in so far as they indicate no inhibition or even facilitation for the pleasant lists, and but slight inhibition for the indifferent lists, support the negative findings of De Camp. However, in so far as when combined with Experiment 1 they present a uniform tendency for retroactive inhibition to appear more *readily* in the indifferent lists, they point to a new and striking possibility; the possibility, namely, that in the case of two contrasted conditions of learning, one condition may be consistently more affected by retroactive inhibition than the other.

It was precisely to test out this possibility further that the succeeding experiments were undertaken. A difficulty encoun-

tered with the present experiments was that the difference in feeling-tone was for most subjects in all probability but slight. This fact appeared particularly in the last three experiments, not only from the special tests to measure relative stimulating values, but also from incidental introspection. Because of this condition, which may well have been the cause in part for the somewhat indecisive character of the results, we decided to substitute for pleasantness and indifference some other pair of conditions which might present a more constant but similar contrast. In the pursuance of this problem we attempted, first, a comparison of the results of learning under normal attention with those of learning under divided attention. The results of the experiment are given in the next section.

II. Normal vs. Distracted Attention. Exp. 5.

The distracted attention was brought about as follows. A telegraph key was connected with contacts upon the drum in such a way that it tapped a group of one, two, or three taps simultaneously with the presentation of every pair of list elements. The subject at the same time that she was reading the lists was required to duplicate the taps by striking a pencil on the table. The distraction thus obtained was very considerable and yet not so great but that the subject was quite able to read the list correctly and to make progress towards learning it. The grouping of the taps was different for successive repetitions, so that the degree of distraction remained practically constant throughout the entire presentation of a list. The other conditions and results were as follows.

Experiment 5. Subject T.

Kymograph drum. Electric motor. Time of one rev. 12.0 sec. Response times not measured. Twelve-place lists of alternate nonsense syllables and one-syllable words. Systematic variation of the time-position of lists. Cycle of variations complete in four experiment-hours. Repetitions: normal lists 7-6, average 6.4; lists with distracted attention 18-14, average 16.8. Time-interval 6 minutes. Work: 2 min. studying checkerboard of consonants or numbers (on alternate days).

Examining the complete results, we observe no appreciable tendency for either condition to show more retroactive inhibition

		Normal Attention			Distracted Attention	
		r			*r*	
Complete results.	P	43.1	(33.3)	p	41.7	(33.3)
(12 exp.-days)	W	37.5	(33.3)	w	37.5	(33.3)
n=72						
		Nos.	*Cons.*		*Nos.*	*Cons.*
Work:		14.2	10.9		14.4	10.2
		r			*r*	
First cycle	P	29.2	(25.0)	p	54.2	(50.0)
(4 exp.-days)	W	29.2	(25.0)	w	29.2	(33.3)
n=24						
		r			*r*	
Second cycle	P	50.0	(50.0)	p	29.2	(25.0)
(4 exp.-days)	W	45.8	(33.3)	w	41.7	(41.7)
n=24						
		r			*r*	
Third cycle	P	50.0	(50.0)	p	41.7	(41.7)
(4 exp.-days)	W	37.5	(41.7)	w	41.7	(50.0)
n=24						

than the other. The individual cycles confirm this finding. The results for the successive cycles do not agree with one another, and hence the negative outcome of the complete results was to be expected. We may note, finally, that these negative results not only show no greater evidence of inhibition for one condition than for the other, but also very little inhibition for either condition. In short, De Camp's completely negative findings tend to be supported.

We conclude that this comparison of normal and distracted attention did not present the contrast between a condition more susceptible to inhibition and one less susceptible to inhibition which we were looking for.

In the next section we present experiments contrasting the effects upon retroactive inhibition of learning with caffeine and of learning without caffeine.

III. With Caffeine vs. without Caffeine. Exps. 6 and 7.

The general conditions of the experiment were as follows.

1½ grain capsules of caffeine were taken by the subjects on alternate days. Sugar of milk capsules of similar appear-

ance were given on the in-between days. The subjects were thus unaware which were the caffeine days and which the non-caffeine days. The capsules were given sometimes before, sometimes at, and sometimes just after the morning meal. The experiments were performed on an average of 2½ to 3 hours later. Schedules of the exact hours are presented below. The subjects refrained from all use of tea, coffee, or chocolate throughout the course of the experiment.[9]

Experiment 6. Subject To.

In this experiment the writer himself acted as subject. He remained totally ignorant of the way in which the results were coming out until after the conclusion of the experiment.[10] Previous to the time of the experiment he had been an occasional user only of coffee, tea, or chocolate.

The schedule of hours at which capsules were administered and experiments performed is given below.

Date	*Capsule.*	*Hour for Capsule.*	*Hour of Exp.*	
May 31	Caffeine	8.30	11.00	Practice
June 1	S of M	8.30	11.00	Main Exp.
" 2	Caffeine	7.10	11.00	" "
" 3	S of M	7.45	11.00	" "
" 4	Caffeine	9.00 Sunday	No Exp.	
" 5	S of M	8.15	11.20	" "
" 6	Caffeine	8.15	11.00	" "
" 7	S of M	8.15	11.00	" "
" 8	Caffeine	8.30	11.00	" "
" 9	S of M	8.30	No Exp.	
" 10	Caffeine	8.30	" "	
" 11	S of M	8.30	" "	
" 12	Caffeine	8.45	11.00	" "

In each experiment hour four lists were learned, two with work and two without. Kymograph drum, electric motor. Time of one rev. 9.0 secs. Response times measured. Lip-key style A. Twelve-place nonsense syllable lists. Systematic variation of the time-position of the lists. Cycle of variation complete in eight experiment-hours. Repetitions: with caffeine 10-9,

[9] The general method of procedure as regards caffeine was an adaptation from that presented by Hollingworth, H. L., Archives of Psychology, Vol. XX, No. 4.

[10] The writer's acknowledgements are due to Miss Esther Watt, A.M. in psychology, who served as experimenter.

average 9.5; without caffeine 11-10, average 10.5. Time-interval 7½ minutes. Work: 2 min. studying checkerboard of consonants.

		With Caffeine.			Without Caffeine.	
		r			*r*	
Complete results.	P	37.5	(33.3)	p	50.0	(50.0)
(8 exp.-days)	W	41.7	(41.7)	w	27.1	(25.0)
n=48.						
		TA	T<2 sec.		TA	T<2 sec.
	P	4.5	9	p	6.3	7
	W	6.0	9	w	6.1	2
		Cons.			*Cons.*	
Work:		20.6			19.4	

Under the caption TA are given the average times for the correct responses; under T<2 sec., the absolute number of correct responses with time equal to or less than 2.0 sec.[11] The other symbols have the same meaning as in previous tables.

The values for the percentages of correct responses show no inhibition for the caffeine days, but decided inhibition for the non-caffeine days, and this, although the work accomplished in terms of the number of consonants learned seems to have been greater for the caffeine than for the non-caffeine days. This bears out our supposition that caffeine and non-caffeine might give results similar to those obtained from pleasant and indifferent lists.

We shall not now discuss the time-values. Taken separately they indicate no very clear conclusion. We shall therefore reserve our discussion of them until we have obtained those for all the other experiments in which times were measured.

Let us turn now to the second experiment upon the effects of caffeine.

Experiment 7. Subject T.

The general conditions were similar to those for the preceding experiment.

The schedule for caffeine and sugar of milk capsules is shown below.

[11] In thus presenting the numbers of relatively short times in addition to the mean times we have followed the precedent of Müller and Pilzecker. See op. cit., pp. 41-43.

Date	*Capsule.*	*Hour for Capsule.*	*Hour of Exp.*	
July 1	Caffeine	9.00	12.00	Practice.
" 2	S of M	9.00	12.00	Main Exp.
" 3	Caffeine	8.10	11.20	" "
" 4	S of M	8.25	11.30	" "
" 5	Caffeine	8.10	11.30	" "
" 6	S of M	8.20	11.20	" "
" 7	Caffeine	8.30	11.30	" "
" 8	S of M	8.30	11.30	" "
" 9	Caffeine	9.30	12.30	" "
" 10	S of M	8.30	11.30	" "
" 11	Caffeine	8.30	11.30	" "
" 12	S of M	8.00	11.00	" "
" 13	Caffeine	7.30	10.45	" "

In each experiment-hour 4 lists were learned, two with work and two without. R. L. Gedächtnisapparat. Time of one rev. 10.8 sec. Response times measured. Lip-key, style B. Twelve-place nonsense syllable lists. Systematic variation of the time-position of the lists. Cycle of variation for both with caffeine and without caffeine, complete in four exp.-hours. Repetitions: with caffeine 15, average 15.0; without caffeine 15-13, average 13.8. Time-interval 7½ minutes. Work: 2 min. studying checkerboard of consonants.

		With Caffeine.		Without Caffeine.	
		r		*r*	
Complete results.	P	41.7	(33.3)	p 55.6	(58.3)
(12 exp.-days)	W	29.2	(33.3)	w 30.6	(33.3)
n=72.					
		TA	T<1.4sec.	TA	T<1.4sec.
	P	1.8	20	p 2.3	16
	W	1.9	7	w 2.7	5
Work:		*Cons.*		*Cons.*	
		21.0		19.4	
		r		*r*	
First Cycle	P	58.3	(58.3)	p 50.0	(58.3)
(4 exp.-days)	W	20.8	(16.7)	w 29.2	(33.3)
n=24					
		r		*r*	
Second Cycle	P	33.3	(33.3)	p 50.0	(50.0)
(4 exp.-days)	W	45.9	(50.0)	w 29.2	(33.3)
n=24					
		r		*r*	
Third Cycle	P	33.3	(25.0)	p 66.7	(66.7)
(4 exp.-days)	W	20.8	(25.0)	w 33.3	(33.3)
n=24					

Examining the percentages of correct responses for the complete results, we again find greater inhibition for the days without caffeine than for those with caffeine,[12] and this result is carried out by the figures for the last two cycles. It is to be noted that the number of consonants learned was greater for the caffeine than for the non-caffeine days. The time-values will be discussed later.

We conclude that these results substantiate those for the preceding experiment. Because, however, of the difficulties connected with the strict regimen required of the subjects, no further experiments using caffeine were undertaken.

As a final method of presenting more and less stimulating conditions, we tried the effects of relatively efficient and inefficient working periods of the day. To those experiments we now turn.

IV. Efficient vs. Inefficient Working Periods. Exps. 8, 9, 10, 11, 12, and 13.

In these experiments the results for lists learned in a morning period were compared with those for lists learned directly after the mid-day meal, or, in the case of two experiments, with those for lists learned in the evening. In each learning period two lists were learned: one a "passive" and one a "work" list. Whether the "passive" or the "work" list was to come first could not be guessed beforehand by the subject, as the two orders, 'work' 'passive,' and 'passive' 'work,' were mixed haphazard throughout a cycle (Irregular variation of time-positions). A cycle consisted of six (or in some cases four) experiment days in which the two orders, 'work' 'passive' and 'passive' 'work', occurred in equal numbers both in the efficient and in the inefficient periods. Other conditions were similar to those in the preceding experiments.

[12] The average value for the w lists for the non-caffeine days is, to be sure, not quite as small as that for the caffeine days. The difference is so slight, however, that it hardly seems a significant deviation from our prescribed rule, especially since the median values fulfill the requirement. A few less repetitions on the days without caffeine would easily have reduced *r* for w to that for W, without making *r* for p as small as that for P.

Experiment 8. Subject C. Morning and Evening.

R. L. Gedächtnisapparat. Time of one rev. 10.8 sec. Response times measured. Lip-kep style B. Ten-place nonsense syllable lists. Irregular variation of the time-position of the lists. Two cycles of variation: first complete in 6 days; second complete in 4 days. Repetitions: morning 13-8 average 9.5; evening 26-20, average 21.8. Time-interval 8½ minutes. Work: 2 min. studying checkerboard of numbers.

		Morning.			Evening.	
		r			*r*	
Complete results.	P	44.0	(40.0)	p	52.0	(60.0)
(10 exp.-days)	W	42.0	(50.0)	w	34.0	(20.0)
n=50						
		T_A	T<2.0sec.		T_A	T<2.0sec.
	P	3.5	9	p	4.3	4
	W	4.7	7	w	5.7	4
		Nos.			*Nos.*	
Work:		12.4			12.4	
		r			*r*	
First Cycle	P	53.3	(60.0)	p	53.3	(50.0)
(6 exp.-days)	W	46.7	(60.0)	w	26.7	(20.0)
n=30						
		r			*r*	
Second Cycle	P	30.0	(30.0)	p	50.0	(60.0)
(4 exp.-days)	W	35.0	(30.0)	w	45.0	(50.0)
n=20						

The values for the percentages indicate quite decidedly bigger inhibition for the evening than for the morning. We find this to be true not only for the final results but also for the individual cycles. The average number of numbers remembered was the same for both conditions. The time values will be considered later.

The next experiment was performed with the same subject. An interval of three weeks elapsed between the two experiments. The results are similar to the above though not perhaps as decisive.

Experiment 9. Subject C. Morning and Evening.

One cycle only, complete in 6 days. Repetitions: morning 12-8, average 9.3; evening 15-10, average 12.5. Other conditions same as in Exp. 8.

		Morning.			Evening.	
		r			*r*	
Complete results.	P	36.7 (40.0)		p	43.3 (40.0)	
(6 exp.-days)	W	26.7 (30.0)		w	26.7 (30.0)	
n=30						
		TA	T<1.8sec.		TA	T<1.8sec.
	P	2.8	3	p	3.2	3
	W	5.7	3	w	3.9	1
		Nos.			*Nos.*	
Work:		14.5			13.7	

The percentages of correct responses indicate only a slightly greater inhibition for the evening than for the morning. More numbers were learned for work in the morning than in the evening. Time values will be discussed later.

In comparing these results with those of the two cycles of the preceding experiment, it will be observed that the first cycle of the preceding experiment gave the most pronounced results, the second cycle of that experiment came next, while the one cycle of this experiment comes last. Now it is to be noted that these experiments were performed during the summer vacation, and that at the beginning of the first one the subject was tired as a result of a strenuous winter, but as they went on she became more and more rested. (She testified to this herself without at all knowing the purpose of the experiment.) If, now, we may assume that her general tired condition at the beginning of the first experiment tended to affect the evening hour relatively more than the morning hour, but that as she became gradually more rested the difference in efficiency between the two periods tended to disappear, we have an explanation for the decrease in the clearness of the results as the experiments progressed. That such an assumption is justifiable the writer firmly believes. It accords with his personal observation of the subject at the time, and also with the objective fact that as the experiments progressed the excess number of repetitions which had to be given in the evening was much cut down. In the first of the two experiments (see above), the evening repetitions varied from 26 to 20, average 21.8; the morning repetitions varied from 13 to 8, average 9.7. In the second experiment,

the morning repetitions varied from 12 to 8, average 9.3; the evening repetitions, on the other hand, were reduced to a variation of only 15 to 10, average 12.5. These figures seem to indicate that in the earlier experiment the evening hour was relatively much more inefficient as compared with the morning hour than in the later experiment. Hence the more pronounced results of the first experiment.

We turn now to the next experiment, using a different subject.

Experiment 10. Subject T. Morning vs. Afternoon (directly after the mid-day meal).

One cycle only, complete in 6 days. Repetitions: morning 12-8, average 9.7; afternoon 18-12, average 14.8. Other conditions same as in Experiments 8 and 9.

		Morning.			Afternoon.	
		r			*r*	
Complete results.	P	50.0 (50.0)		p	50.0 (50.0)	
(6 exp.-days)	W	36.7 (40.0)		w	23.3 (20.0)	
n=30						
		T_A	T<1.2sec.		T_A	T<1.2sec.
	P	1.8	5	p	1.9	3
	W	2.2	2	w	2.0	2
		Nos.			*Nos.*	
Work:		11.1			11.3	

Both the average and median percentages of correct responses show greater inhibition for the afternoon than for the morning. A slightly bigger average for the numbers learned in work was obtained for the afternoon. The time values will be considered later.

The same subject was used in the next experiment. An interval of five weeks elapsed between the two experiments.

Experiment 11. Subject T. Morning vs. Afternoon (directly after the mid-day meal).

One cycle only, complete in 6 days. Repetitions: morning 9, average 9.0; afternoon 14, average 14.0. Other conditions same as in Exps. 8, 9, and 10.

		Morning.			Afternoon.	
		r			*r*	
Complete results.	P	56.7 (60.0)		p	56.7 (50.0)	
(6 exp.-days)	W	43.3 (50.0)		w	26.7 (30.0)	
n=30						
		TA	T<1.6sec.		TA	T<1.6sec.
	P	1.9	7	p	2.0	6
	W	2.8	4	w	2.0	4
		Nos.			*Nos.*	
Work:		13.3			12.3	

Again we find greater inhibition for the afternoon than for the morning. More numbers were learned in the morning than in the afternoon hour. The time values will be discussed later.

The final experiments were performed on a third subject.

Experiment 12. Subject Ca. Morning vs. Afternoon (directly after the mid-day meal).

One cycle only, complete in 6 days. Repetitions: morning 8-6, average 7.2; afternoon 10-7, average 9.0. Other conditions same as in Exps. 8, 9, 10, and 11.

		Morning.			Afternoon.	
		r			*r*	
Complete results.	P	66.7 (70.0)		p	66.7 (80.0)	
(6 exp.-days)	W	60.0 (60.0)		w	50.0 (40.0)	
n=30						
		TA	T<2.2sec.		TA	T<2.2sec.
	P	4.8	10	p	6.0	5
	W	4.3	7	w	4.5	5
		Nos.			*Nos.*	
Work:		17.0			14.3	

Again greater inhibition is found for the afternoon. This time the average for the numbers learned was much greater for the morning work than for the afternoon work. Time values will be discussed later.

The next experiment, which used the same subject, succeeded this one after an interval of 9 days.

Experiment 13. Subject Ca. Morning vs. Afternoon (directly after the mid-day meal).

Two cycles. First cycle complete in 6 days; second cycle complete in 4

days. Repetitions: morning 6-4, average 4.5; afternoon 10-7, average 8.4. Other conditions same as in Exps. 8, 9, 10, 11, and 12.

		Morning.			Afternoon.	
		r			*r*	
Complete results.	P	54.0	(40.0)	p	68.0	(70.0)
(10 exp.-days)	W	56.0	(60.0)	w	48.0	(40.0)
n=50						
		T_A	$T<1.4$sec.		T_A	$T<1.4$sec.
	P	2.9	13	p	4.7	6
	W	3.4	9	w	5.2	8
		Nos.			*Nos.*	
Work:		19.4			16.7	
		r			*r*	
First Cycle	P	60.0	(50.0)	p	66.7	(70.0)
(6 exp.-days)	W	53.0	(60.0)	w	46.7	(40.0)
n=30						
		r			*r*	
Second Cycle	P	45.0	(40.0)	p	70.0	(70.0)
(4 exp.-days)	W	60.0	(70.0)	w	50.0	(50.0)
n=20						

Again all the figures for percentages of correct responses, those for the individual cycles as well as the complete results, show greater inhibition for the afternoon than for the morning. Time values will be discussed in the next section.

Reviewing the results for these six experiments, we find that *without exception the lists learned in the inefficient hour of the day showed more inhibition, in terms of percentages of correct responses, than did those learned in the efficient hour of the day.*

V. Numbers of Repetitions; Work.

It has already been remarked[16] that our choice of the terms More and Less Stimulating to cover the contrasts pleasant and indifferent, with caffeine and without caffeine, efficient period and inefficient period, was due to certain characteristics common to these contrasts, aside from that of their behavior as to retroactive inhibition. These other characteristics concern: (1) the relative numbers of repetitions required to produce the same amount of learning, (2) the relative amounts of work accom-

[16] Above: footnote, p. 3.

plished in equal work periods, and (3) the relative times for the correct responses.

Let us consider these factors in order. The first two will be summarized in the present section, the last of the three in the following one.

The relative numbers of repetitions required to produce the same amount of learning (or the complementary fact of the relative amounts of learning produced by the same number of repetitions) we will designate *learnability*. Turning to this learnability as expressed in the relative numbers of repetitions for the contrasted kinds of lists, we are led to the following analysis.

It will be recalled that in order to insure a percentage of correct responses for the p lists as big as or bigger than that for the P lists we gave as a rule more repetitions to the former than to the latter. Now, in those cases where it appears that this excess of repetitions raised the percentage of correct responses of the former to only about equal to that for the latter, we will have evidence that the latter possessed greater learnability than the former. In the cases, however, where it appears that the excess of repetitions raised the percentage of correct responses of the p lists to more than that for the P lists, the evidence of greater learnability for the latter will not be so clear unless, indeed, the excess in repetitions for the p lists is obviously incommensurably great as compared with the excess in percentage of correct responses produced.

The following table summarizes the results for all 13 experiments.

R stands for average number of repetitions and *r* for average percentage of correct responses. P and p stand for More Stimulated and Less Stimulated Passive lists, respectively.

The figures for Experiment 5 (normal vs. distracted attention) may be eliminated at once from present consideration; for, although they indicate enormously more repetitions for the p lists than for the P lists, together with only about equal percentages of correct responses, the fact that this experiment failed to show the characteristic difference as to retroactive inhibition excludes it from our present interest.

Exp.		R		r	
		P	p	P	p
Pleasant vs. Indifferent	1	2.5	3.1	60.0	80.0
	2	8.9	9.8	52.1	60.0
	3	8.9	10.9	52.5	52.5
	4	7.6	8.6	42.5	46.3
Normal vs. Distracted	5	6.4	16.8	43.1	41.7
Caffeine vs. without Caffeine	6	9.5	10.5	37.5	50.0
	7	13.8	15.0	41.7	55.6
Efficient vs. Inefficient	8	9.5	21.8	44.0	52.0
	9	9.3	12.5	36.7	43.3
	10	9.7	14.8	50.0	50.0
	11	9.0	14.0	56.7	56.7
	12	7.2	9.0	66.7	66.7
	13	4.5	8.4	54.0	68.0

Turning to the other twelve experiments for each of which some evidence of greater inhibition for the Less Stimulating condition was found, we note among the four pleasant vs. indifferent experiments one (Exp. 3) for which the percentage of correct responses for p is no greater than that for P, although the average number of repetitions for the former is greater, and one other experiment (Exp. 4) for which the percentage of correct responses for p is only slightly greater, although the number of repetitions is decidedly greater. For these two experiments, therefore, the figures show evidence of greater learnability (i.e., Greater Stimulating value) for the P lists. For the other two pleasant vs. indifferent experiments, on the other hand, the figures point to no certain conclusion.

It is evident, however, that in the case of the pleasant vs. indifferent experiments we have other independent evidence of relative learnability: namely, the evidence presented by our subsidiary experiments. Referring back to these we find that for Experiment 1 the subsidiary experiment seemed to show decided evidence of greater learnability for the pleasant (P) lists. For Experiment 2, on the other hand, the two subsidiary experiments contradicted one another. For Experiments 3 and 4 the subsidiary experiments agreed with the present figures in indicating

greater learnability for pleasant (P) lists. Only, then, in the case of Experiment 2 does any doubt still remain. In the three other experiments the evidence is clear of greater learnability for the pleasant (P) lists.

Turn again to the table for the caffeine experiments. In Experiment 6 the excess in repetitions for the p lists does not seem great as compared with that in percentage of correct responses. In Experiment 7, on the other hand, it does. We would be inclined to urge that the figures for these two experiments combined would not disprove a slight tendency for greater learnability for the caffeine (P) condition.

Examining the table in the case of the efficient vs. inefficient experiments, we note decided evidence for greater learnability for the efficient condition. In three experiments, 10, 11, and 12, the percentages of correct responses are only equal, although the numbers of repetitions are decidedly greater for the p lists than for the P lists. In two other experiments, 8 and 13, the percentages of correct responses are only slightly greater for the p lists than for the P lists, although the numbers of repetitions are approximately twice as great for the former. In the one remaining experiment only, Experiment 9, is the evidence uncertain. Taking the six experiments as a whole, therefore, the figures point to a very decidedly greater learnability for the efficient (P) condition.

To sum up, in one of the three cases, caffeine vs. without caffeine, the evidence is inconclusive; in the other two cases, pleasant vs. indifferent, and efficient period vs. inefficient period, it is decidedly in the direction of greater learnability for the (P) condition.

Let us turn now to the figures for work. The following table includes the results of the work for all 13 experiments.

Before examining the table, we may draw attention to the fact that it is only in the figures for the experiments concerning caffeine vs. without caffeine and efficient periods vs. inefficient periods that we should expect a consistent difference, since it is only in these two sets of experiments that the contrasts could be expected to affect anything other than the immediate lists themselves. Obviously the contrast of pleasant vs. indifferent

	Exp.	M Condition.		L Condition.	
		Nos.	Cons.	Nos.	Cons.
	1	15.0	10.5	15.8	10.0
Pleasant	2	14.0	10.3	10.6	9.7
vs. Indiff.	3		6.4		7.1
	4		14.1		14.1
Normal vs. Distracted.	5	14.2	10.9	14.4	10.2
Caffeine vs.	6		20.6		19.4
without Caffeine.	7		21.0		19.4
	8	12.4		12.4	
	9	14.5		13.7	
Efficient vs.	10	11.1		11.3	
Inefficient.	11	13.3		12.3	
	12	17.0		14.3	
	13	19.4		16.7	

affects the lists only, as also that of normal vs. distracted attention. Turning to the table, we find among the four pleasant vs. indifferent experiments one, Exp. 3, in which the work averaged more for the indifferent lists; one, Exp. 2, in which the reverse was true; one, Exp. 4, in which the works are equal; and one, Exp. 1, in which the figures for the two kinds of work contradict one another. In Exp. 5, that of normal vs. distracted attention, the figures also contradict one another. The expected result, in short, of no consistently greater work for the M condition than for the L condition was obtained.

Examining the table as regards the caffeine vs. without caffeine and the efficient period vs. inefficient period experiments: in six out of the eight, the figures show more work for the M condition; in another, Exp. 8, equal work; and in one, Exp. 10, approximately equal work for the two conditions. It appears that the figures for work further justify the terms "More" and "Less Stimulating."[14]

In the next section we turn to a discussion of time values.

[14] This review of the work figures has another significance. For, if it had appeared that more work had tended, generally speaking, to be accomplished in the L condition, then it might have been claimed that the greater inhibition found for that condition was the result of the greater work. This has already been touched upon in our discussion of individual experiments.

plished in equal work periods, and (3) the relative times for the correct responses.

Let us consider these factors in order. The first two will be summarized in the present section, the last of the three in the following one.

The relative numbers of repetitions required to produce the same amount of learning (or the complementary fact of the relative amounts of learning produced by the same number of repetitions) we will designate *learnability*. Turning to this learnability as expressed in the relative numbers of repetitions for the contrasted kinds of lists, we are led to the following analysis.

It will be recalled that in order to insure a percentage of correct responses for the p lists as big as or bigger than that for the P lists we gave as a rule more repetitions to the former than to the latter. Now, in those cases where it appears that this excess of repetitions raised the percentage of correct responses of the former to only about equal to that for the latter, we will have evidence that the latter possessed greater learnability than the former. In the cases, however, where it appears that the excess of repetitions raised the percentage of correct responses of the p lists to more than that for the P lists, the evidence of greater learnability for the latter will not be so clear unless, indeed, the excess in repetitions for the p lists is obviously incommensurably great as compared with the excess in percentage of correct responses produced.

The following table summarizes the results for all 13 experiments.

R stands for average number of repetitions and *r* for average percentage of correct responses. P and p stand for More Stimulated and Less Stimulated Passive lists, respectively.

The figures for Experiment 5 (normal vs. distracted attention) may be eliminated at once from present consideration; for, although they indicate enormously more repetitions for the p lists than for the P lists, together with only about equal percentages of correct responses, the fact that this experiment failed to show the characteristic difference as to retroactive inhibition excludes it from our present interest.

Exp.		R		r	
		P	p	P	p
	1	2.5	3.1	60.0	80.0
Pleasant vs.	2	8.9	9.8	52.1	60.0
Indifferent	3	8.9	10.9	52.5	52.5
	4	7.6	8.6	42.5	46.3
Normal vs. Distracted	5	6.4	16.8	43.1	41.7
Caffeine vs.	6	9.5	10.5	37.5	50.0
without Caffeine	7	13.8	15.0	41.7	55.6
	8	9.5	21.8	44.0	52.0
	9	9.3	12.5	36.7	43.3
Efficient vs.	10	9.7	14.8	50.0	50.0
Inefficient	11	9.0	14.0	56.7	56.7
	12	7.2	9.0	66.7	66.7
	13	4.5	8.4	54.0	68.0

Turning to the other twelve experiments for each of which some evidence of greater inhibition for the Less Stimulating condition was found, we note among the four pleasant vs. indifferent experiments one (Exp. 3) for which the percentage of correct responses for p is no greater than that for P, although the average number of repetitions for the former is greater, and one other experiment (Exp. 4) for which the percentage of correct responses for p is only slightly greater, although the number of repetitions is decidedly greater. For these two experiments, therefore, the figures show evidence of greater learnability (i.e., Greater Stimulating value) for the P lists. For the other two pleasant vs. indifferent experiments, on the other hand, the figures point to no certain conclusion.

It is evident, however, that in the case of the pleasant vs. indifferent experiments we have other independent evidence of relative learnability: namely, the evidence presented by our subsidiary experiments. Referring back to these we find that for Experiment 1 the subsidiary experiment seemed to show decided evidence of greater learnability for the pleasant (P) lists. For Experiment 2, on the other hand, the two subsidiary experiments contradicted one another. For Experiments 3 and 4 the subsidiary experiments agreed with the present figures in indicating

greater learnability for pleasant (P) lists. Only, then, in the case of Experiment 2 does any doubt still remain. In the three other experiments the evidence is clear of greater learnability for the pleasant (P) lists.

Turn again to the table for the caffeine experiments. In Experiment 6 the excess in repetitions for the p lists does not seem great as compared with that in percentage of correct responses. In Experiment 7, on the other hand, it does. We would be inclined to urge that the figures for these two experiments combined would not disprove a slight tendency for greater learnability for the caffeine (P) condition.

Examining the table in the case of the efficient vs. inefficient experiments, we note decided evidence for greater learnability for the efficient condition. In three experiments, 10, 11, and 12, the percentages of correct responses are only equal, although the numbers of repetitions are decidedly greater for the p lists than for the P lists. In two other experiments, 8 and 13, the percentages of correct responses are only slightly greater for the p lists than for the P lists, although the numbers of repetitions are approximately twice as great for the former. In the one remaining experiment only, Experiment 9, is the evidence uncertain. Taking the six experiments as a whole, therefore, the figures point to a very decidedly greater learnability for the efficient (P) condition.

To sum up, in one of the three cases, caffeine vs. without caffeine, the evidence is inconclusive; in the other two cases, pleasant vs. indifferent, and efficient period vs. inefficient period, it is decidedly in the direction of greater learnability for the (P) condition.

Let us turn now to the figures for work. The following table includes the results of the work for all 13 experiments.

Before examining the table, we may draw attention to the fact that it is only in the figures for the experiments concerning caffeine vs. without caffeine and efficient periods vs. inefficient periods that we should expect a consistent difference, since it is only in these two sets of experiments that the contrasts could be expected to affect anything other than the immediate lists themselves. Obviously the contrast of pleasant vs. indifferent

	Exp.	M Condition.		L Condition.	
		Nos.	Cons.	Nos.	Cons.
	1	15.0	10.5	15.8	10.0
Pleasant	2	14.0	10.3	10.6	9.7
vs. Indiff.	3		6.4		7.1
	4		14.1		14.1
Normal vs. Distracted.	5	14.2	10.9	14.4	10.2
Caffeine vs.	6		20.6		19.4
without Caffeine.	7		21.0		19.4
	8	12.4		12.4	
	9	14.5		13.7	
Efficient vs.	10	11.1		11.3	
Inefficient.	11	13.3		12.3	
	12	17.0		14.3	
	13	19.4		16.7	

affects the lists only, as also that of normal vs. distracted attention. Turning to the table, we find among the four pleasant vs. indifferent experiments one, Exp. 3, in which the work averaged more for the indifferent lists; one, Exp. 2, in which the reverse was true; one, Exp. 4, in which the works are equal; and one, Exp. 1, in which the figures for the two kinds of work contradict one another. In Exp. 5, that of normal vs. distracted attention, the figures also contradict one another. The expected result, in short, of no consistently greater work for the M condition than for the L condition was obtained.

Examining the table as regards the caffeine vs. without caffeine and the efficient period vs. inefficient period experiments: in six out of the eight, the figures show more work for the M condition; in another, Exp. 8, equal work; and in one, Exp. 10, approximately equal work for the two conditions. It appears that the figures for work further justify the terms "More" and "Less Stimulating."[14]

In the next section we turn to a discussion of time values.

[14] This review of the work figures has another significance. For, if it had appeared that more work had tended, generally speaking, to be accomplished in the L condition, then it might have been claimed that the greater inhibition found for that condition was the result of the greater work. This has already been touched upon in our discussion of individual experiments.

VI. Time Values.

In the present section we will briefly group together the values for the times of the correct responses. These were obtained for the caffeine vs. without caffeine and the efficient period vs. inefficient period experiments only. The figures are shown in the following table. The captions have the same meaning as in the previous sections.

		Caffeine.			Without Caffeine.	
		T_A	$T<$2.0sec.		T_A	$T<$2.0sec.
Exp. 6	P	4.5	9	p	6.3	7
n=48	W	6.0	9	w	6.1	2
		T_A	$T<$1.4sec.		T_A	$T<$1.4sec.
Exp. 7	P	1.8	20	p	2.3	16
n=72	W	1.9	7	w	2.7	5
		Efficient Hour.			Inefficient Hour.	
		T_A	$T<$2.0sec.		T_A	$T<$2.0sec.
Exp. 8	P	3.5	9	p	4.3	4
n=50	W	4.7	7	w	5.7	4
		T_A	$T<$1.8sec.		T_A	$T<$1.8sec.
Exp. 9	P	2.8	3	p	3.2	3
n=30	W	5.7	3	w	3.9	1
		T_A	$T<$1.2sec.		T_A	$T<$1.2sec.
Exp. 10	P	1.8	5	p	1.9	3
n=30	W	2.2	2	w	2.0	2
		T_A	$T<$1.6sec.		T_A	$T<$1.6sec.
Exp. 11	P	1.9	7	p	2.0	6
n=30	W	2.8	4	w	2.0	4
		T_A	$T<$2.2sec.		T_A	$T<$2.2sec.
Exp. 12	P	4.8	10	p	6.0	5
n=30	W	4.3	7	w	4.5	5
		T_A	$T<$1.4sec.		T_A	$T<$1.4sec.
Exp. 13	P	2.9	13	p	4.7	6
n=50	W	3.4	9	w	5.2	8

Let us examine the above table. Comparing the results for the passive lists, we note that in every case the mean time for p was longer than for P, and that in every case but one (Exp. 9), the number of short response times was consistently less for p than for P. This fact that *the times for the passive lists always tended to be longer for the Less Stimulating than for the More Stimulating condition* is important. It holds in spite of the fact that the percentages of correct responses were as big or bigger for the former than for the latter, and it therefore points to a

real difference between the two conditions. It constitutes, therefore, a third reason for the designations of "More Stimulating and Less Stimulating."

Turning to the figures for the W and w lists, we note that in general both the average times and the numbers of short times indicate a tendency for longer times for these lists than for the passive lists. They present, in short, further testimony, in addition to that of the percentages of correct responses, of the inhibitory effect of work. When, however, we compare the results for the W and w lists with one another, we find that, in general, the evidence of longer times for the w lists than for the W lists is not quite as great as was that of longer times for the p lists than for the P lists. In only five out of the eight experiments was the mean time for w longer than for W, and in only six of the eight experiments were the numbers of short response times less for the former than for the latter; whereas in the case of the P and p lists we found in every case but one complete evidence of longer times for the latter than for the former.

This difference between the results for the work lists and for the passive lists is the opposite of what we might perhaps have expected offhand. For, since there was greater inhibition for the L condition, as shown by the greater drop in the percentage of correct responses from p to w than from P to W, we should have expected that if the p lists gave consistently longer times than the P lists, the w lists would have given *even more consistently* longer times than the W lists. Instead we found the opposite.

An explanation suggests itself. The length of time which a response may take and still be successful will not exceed a certain maximum. For, if the response does not come within a relatively short time, the subject abandons the attempt. This means that the weaker the association strengths become and *pari passu* the longer the response times, the less will a further increase in weakness affect the times. And we get such a situation as the present where the effect of the work seems to have been to wipe out to some extent the previous greater length of the response times for the L condition.

To sum up: We may consider that the time values are interesting primarily not because they add further testimony as to the greater inhibitory action of the L condition, but because, considering them for the passive lists alone, they point to a difference between the effects of the two contrasted conditions which seems to be consonant with and to further amplify the difference found in the numbers of repetitions required and in the amounts of work accomplished.

In the next chapter we present a summary and discussion of our results.

CHAPTER V

SUMMARY AND DISCUSSION

Our results, briefly, are:

I. Pleasant lists, learned with caffeine, and lists learned in an efficient hour of the day (More Stimulating conditions) tended to be less affected by work, i.e., to show less evidence of retroactive inhibition, than did indifferent lists, lists learned without caffeine, and lists learned in an inefficient hour of the day, respectively (Less Stimulating conditions).

II. *Pleasant lists, lists learned with caffeine, and lists learned in an efficient hour of the day (More Stimulating conditions) all seemed to require fewer repetitions for the same amounts of learning than the respectively contrasted indifferent lists, lists learned without caffeine, and lists learned in an inefficient hour of the day (Less Stimulating conditions).*

III. *The work accomplished with caffeine and in an efficient hour of the day (More Stimulating conditions) tended to be greater than that accomplished without caffeine and in an inefficient hour of the day (Less Stimulating conditions).*

IV. *Lists learned with caffeine and in an efficient hour of the day (More Stimulating conditions) tended in the case of the passive lists to have shorter response times than lists learned without caffeine and in an inefficient hour of the day (Less Stimulating conditions).*

V. *Lists learned under normal attention and lists learned under artificially distracted attention differed only as to the numbers of repetitions required for equal learning.*

To explain the differences between the inhibition effects in the More and Less Stimulating conditions, two hypotheses, and only two at present, suggest themselves. They both originate from the longer average response times for the passive lists of the L condition.[1]

[1] It is, of course, unfortunate that the times were not measured for the pleasant and indifferent lists, but we are assuming that what held for the other pairs of contrasts would have held also for them.

The first hypothesis would assume that this longer time corresponded to relatively more just supraliminal and relatively fewer "over-learned" associations for the L conditions than for the M conditions. Since it already seems to have been established[2] that just supraliminal associations tend to be relatively more affected by retroactive inhibition than are stronger associations, the desired explanation results.

It will be noted that this hypothesis assumes that the M condition for some reason produces less "even" learning than the L condition; that, in other words, in the M condition the easy parts of the list tend to be learned relatively speaking much sooner than the hard parts. Just why, however, such a difference should exist between the effects of the two conditions would be a question for further hypothesis and examination.

Our second hypothesis, on the other hand, assumes that the longer average time for the L condition is not due to any difference in the "evenness" of learning, as such, but to a fundamental neurological difference in the nature of the association bonds formed in the two conditions, such that, given bonds of equal strength, those in the L condition would tend inherently to take a longer response time, and to be more affected by retroactive inhibition than those of the M condition. It would assume, in short, that the underlying neurological conditions which cause the fewer repetitions, the greater accomplishment of work, and the above mentioned shorter response time for the M condition would also have the further effect of causing a less great susceptibility to retroactive inhibition on the part of the association bonds formed in this condition. This second hypothesis seems much the more suggestive and interesting.

At present, however, we have no basis for choosing between the two hypotheses. We simply present them as the only two possible assumptions which occur to us, and leave it for future work to determine between them.[3]

[2] Heine advanced evidence to show that weak associations are relatively more affected by retroactive inhibition than strong ones. Op. cit., pp. 211-225. See also above, pp. 6-7.

[3] Another investigation is already in progress which, it is hoped, will furnish such a decision.

One final question: To what extent do our results throw light on the opposition between De Camp's results and those of Müller and Pilzecker and of Heine? To answer this question we must search for possible outstanding differences between the conditions of the two sets of experiments. Such a careful examination reveals the following points: 1. As work De Camp used some form of mental work other than memorizing;[4] the German experiments used memorizing of other material usually of a quite different sort from the original material. 2. De Camp presented the two syllables of each pair simultaneously, with a wait between each pair, and the time per revolution of the list was relatively great, about 23.7 sec.[5] Müller and Pilzecker and Heine presented all the syllables of the lists successively. The interval between the last syllable of one pair and the first syllable of the next was the same as that between the first syllable and the last syllable of the same pair. The total time of presentation was short, varying from 7.2 sec. to 10.5 sec. per single revolution.[6] 3. De Camp used different subjects from those used by the German experiments, and it is very possible that he also used a different working hour for carrying on his experiments.

Let us now consider these differences from the point of view of any light thrown on them by our results. As regards the first, we used further memorizing just as did Müller and Pilzecker and Heine. Yet we did not find inhibition in all cases. When the learning conditions were More Stimulating, evidences of inhibition were in some cases wholly lacking, and in others much reduced. It would seem, therefore, that memorizing as work does not necessarily mean inhibition. Hence the greater evidence for inhibition obtained by the German investigators is probably not to be attributed entirely, if at all (as De Camp

[4] With the exception of Exps. VIII in which physical work was used (see above, p. 9).

[5] De Camp, op. cit., p. 15. As against this difference is to be reckoned, of course, the fact that De Camp used 14 syllable lists, whereas the German experimenters used none longer than 12.

[6] Müller and Pilzecker, op. cit., pp. 180-190; Heine, op. cit., pp. 187-197, 217-223.

seems to suggest), to the fact that they used further memorizing as work, whereas De Camp used cross-multiplication.

As for the second difference between De Camp's experiments and those of Müller and Pilzecker and of Heine—the mode and rate of presentation—a similar argument holds. Our conditions were again closely similar to those of the German investigators. Yet we did not find inhibition in all cases.

The last differences remain to be discussed; that of different subjects and that of a possible difference in hours of experimenting. These might, we believe, afford a partial explanation. They might be analogous to our More and Less Stimulating conditions. As regards a difference in subjects, our experiments, it is true, do not directly bear. But from the actual carrying of them out, we have become convinced that certain subjects exhibit inhibition much more readily than others; that, in short, they are always "More Stimulated" than others. From a purely speculative point of view this seems a reasonable assumption; viz., that the differences which exist between efficient and inefficient hours and between being with caffeine and without caffeine in the case of any one subject may be duplicated in those existing between subjects. Making such an assumption as regards De Camp's subjects as compared with those of Müller and Pilzecker and of Heine, and assuming further that the hours of the day chosen in some of De Camp's experiments were more efficient than those chosen by the German investigators, we have an explanation of the contradiction between their results.